Examiner contends that the "lamellar liquid crystals" in Kawada meet this limitation. Applicants again respectfully disagree.

As a first point, it should be noted that Kawada does not refer to a "lamellar crystal structure" as the Examiner suggests. Rather, the Kawada at both Col. 11, lines 13-15 and col. 13, lines 50-63 refers to a "lamellar **liquid** crystal." This is consistent with the distinction that Applicants have argued, i.e., that Kawada teaches **liquid crystals**, and not crystals.

The terminology which has been adopted by persons skilled in the art in a bit sloppy, but the fact is that "liquid crystals" are not crystalline. Indeed, Kawada provides data to show that the liquid crystals described in that application do ***not*** crystallize (col. 14, lines 18-19; column 13, lines 51-58). To help the Examiner further understand the distinctions between a crystalline material and a liquid crystal, Applicants point to the discussion on Page 4 of the application. As pointed out there, "a crystalline phase is defined as a physical state in which lipid membranes are organized on a lattice and have extremely reduced lateral and rotation mobility compared to the fluid arrangement of other mammalian cellular membranes." In other words, they are essentially a solid. In contrast, "non-crystalline phases" include liquid crystals, gels, and other recognized non-crystalline phases such as "liquid ordered" phases. As noted liquid crystals have some order, which is why the term "crystal" is used, but they are fluid. Thus, they are not crystalline as that term is used in the specification.

Applicants also attach a description of liquid crystals taken from the University of Wisconsin web site at http://scifun.chem.wisc.edu/chemweek/liqxtal/liqxtal.html. As shown in Fig. 1, and described in the text, crystals have an ordered structure with the molecules in fixed positions. In contrast Fig. 3, shows a lamellar liquid crystal, i.e., one in which the molecules are arranged in layers, or lamellae. This composition is still in a liquid state because the bonding forces are not equal in all directions, allowing both order and fluidity.

For the foregoing reasons, Applicants submit that the Examiner's argument that Kawada teaches the same type of material as the instant claims is not supported by the reference as it would be understood by a person skilled in the art. Accordingly, Applicants submit that the

rejection of the claims should be withdrawn, and that all claims should be allowed. Favorable reconsideration is respectfully requested.

Respectfully Submitted,

Marina T Larson

Marina T. Larson, Ph.D
Attorney for Applicants
Reg. No. 32038

970 468 6600

LIQUID CRYSTALS

To those who know that substances can exist in three states, solid, liquid, and gas, the term "liquid crystal" may be puzzling. How can a liquid be crystalline? However, "liquid crystal" is an accurate description of both the observed state transitions of many substances and the arrangement of molecules in some states of these substances.

Many substances can exist in more than one state. For example, water can exist as a solid (ice), liquid, or gas (water vapor). The state of water depends on its temperature. Below 0°C, water is a solid. As the temperature rises above 0°C, ice melts to liquid water. When the temperature rises above 100°C, liquid water vaporizes completely. Some substances can exist in states other than solid, liquid, and vapor. For example, cholesterol myristate (a derivative of cholesterol) is a crystalline solid below 71°C. When the solid is warmed to 71°C, it turns into a cloudy liquid. When the cloudy liquid is heated to 86°C, it becomes a clear liquid. Cholesterol myristate changes from the solid state to an intermediate state (cloudy liquid) at 71°C, and from the intermediate state to the liquid state at 86°C. Because the intermediate state exits between the crystalline solid state and the liquid state, it has been called the liquid crystal state.

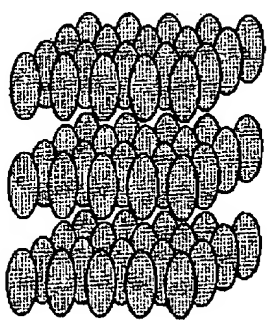

Figure 1. Arrangement of molecules in a solid crystal.

Figure 2. Arrangement of molecules in a liquid.

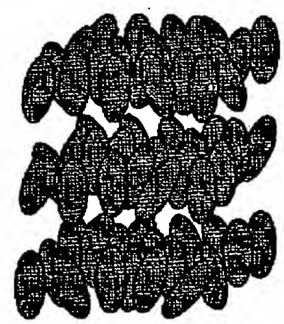

Figure 3. Arrangement of molecules in a liquid crystal.

"Liquid crystal" also accurately describes the arrangement of molecules in this state. In the crystalline solid state, as represented in Figure 1, the arrangement of molecules is regular, with a regularly repeating pattern in all directions. (Molecules of substances with a liquid crystal state are generally oblong and rigid, that is, rod-shaped.) The molecules are held in fixed positions by intermolecular forces. As the temperature of a substance increases, its molecules vibrate more vigorously. Eventually, these vibrations overcome the forces that hold the molecules in place, and the molecules start to move. In the liquid state, this motion overcomes the intermolecular forces that maintain a crystalline state, and the molecules move into random positions, without pattern in location or orientation, as represented in Figure 2.

In materials that form liquid crystals, the intermolecular forces in the crystalline solid are not the same in all directions; in some directions the forces are weaker than in other directions. As such a material is heated, the increased molecular motion overcomes the weaker forces first, but its molecules remain bound by the stronger forces. This produces a molecular arrangement that is random in some directions and regular in others. The arrangement of molecules in one type of liquid crystal is represented in Figure

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3. The molecules are still in layers, but within each layer, they are arranged in random positions, although they remain more or less parallel to each other. Within layers, the molecules can slide around each other, and the layers can slide over one another. This molecular mobility produces the fluidity characteristic of a liquid.

There are other molecular arrangements in liquid crystals. Many liquid crystals of technological significance have the arrangement represented in Figure 4. Liquid crystals with this arrangement are called **twisted nematic** liquid crystals. In this arrangement, the layers contain the long axes of the molecules. Furthermore, the long axes rotate by a small angle from one layer to the next. Twisted nematic liquid crystals are used in temperature-sensing devices that change color. They are also the most common type used in the liquid crystal displays (LCDs) found in calculators and watches. Both of these applications depend on the way liquid crystals interact with light.

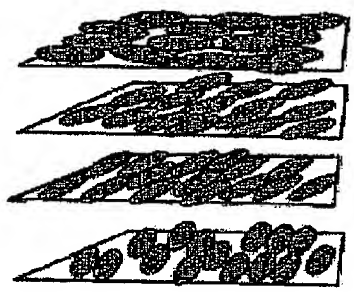

Figure 4. Arrangement of molecules in a twisted nematic liquid crystal.

When light strikes a twisted nematic liquid crystal, some of the light is reflected. Only light with a wavelength equal to the spacing between layers of similar orientation is reflected. Therefore, the reflected light will appear colored. As the temperature of the liquid crystal changes, the spacing between layers also changes. The change in spacing changes the wavelength of the reflected light and its observed color. Therefore, the color of the reflected light is an indication of the temperature of the liquid crystal. Different substances form twisted nematic liquid crystals over different temperature ranges, and so a wide temperature range can be covered by using several substances.

When polarized light passes through a twisted nematic liquid crystal, the plane of polarization rotates. The degree of rotation depends on the number of layers of molecules the light encounters in the liquid crystal. If the axes of the molecules in the layer from which the light exits are at an angle of 90 degrees to those in the layer of entry, then the plane of polarization of the light rotates by 90 degrees. The ability of twisted nematic liquid crystals to rotate the plane of polarized light is exploited in LCDs. Figure 5 is a schematic diagram of an LCD. Ambient light enters from the right and is polarized by a polarizing filter. The polarized light passes through the front glass wall of the display, then through a transparent, electrically conductive coating on the glass, and into the liquid crystal. The thickness of the liquid crystal is sufficient to rotate the plane of the polarized light by 90 degrees. At the back of the display, the light passes through another electrically conductive coating, glass plate, and polarizing filter. This rear polarizing filter is placed with its axis at 90 degrees to the front filter. The polarized light passes through this rear filter, because its polarization was also rotated by 90 degrees by the liquid crystal. At the back of the LCD is a mirror that reflects the light back through the cell. The light retraces its path, and an observer sees the display as relatively bright. When an electric potential is applied between the two conductive coatings, the resulting electric field affects the positions of molecules in the liquid crystal. The molecules tend to turn so they align with the electric field. When this happens, the plane of polarized light passing through the cell is no longer rotated by 90 degrees, and it cannot pass through the rear filter. Therefore, it is no longer reflected back to an observer, and the area appears dark. By the selective charging of areas of the conductive coating, patterns of dark digits or letters against a bright background are formed.

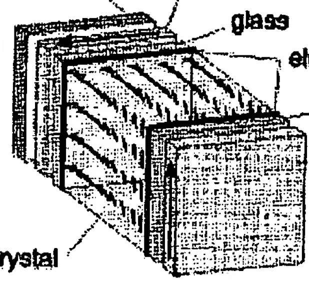

Figure 5. Schematic diagram of liquid crystal display.

Substances that form liquid crystal structures are quite common. Approximately 0.5% of known carbon compounds have liquid crystal states. These structures are especially common in living organisms, where cell walls are composed of molecules in a liquid crystal arrangement of parallel molecules in layers. A more mundane instance of liquid crystals is the opalescent fluid that forms in the bottom of a soap dish. Soap molecules have the appropriate oblong shape and, when mixed with a little water, assume a liquid crystal arrangement.

Back to Chemical of the Week.